THE ROLE OF FLUID MUD IN SEDIMENT TRANSPORT PROCESSES ALONG A MUDDY COAST

Gail C. Kineke
Dept of Geology and Geophysics
Boston College
Chestnut Hill, MA 02167
phone: 617-552-3655 fax: 617-552-2462 email:kinekeg@bc.edu
Award #N00014-96-1-0723

LONG-TERM GOALS

The long-term goals of this study are to evaluate the role of fluid mud in sediment transport processes along muddy coastlines. This requires an understanding of the formation and dynamic behavior of fluid muds, as well as the effects on attenuation of surface waves as they approach the shoreline.

OBJECTIVES

The motivation for this study comes from the acknowledgement that work done on sandy beaches is not directly transferable to muddy coasts, and the role of fluid mud is critical to large-scale beach changes on muddy coasts. This study addresses the following objectives:

1. to examine the formation of fluid mud on the inner shelf as the result of a) trapping due to convergence of bottom flows and enhanced settling at a salinity front, or b) a resuspension process due to surface wave activity;
2. to test the concept of a critical bearing capacity for a flow, based on results of Trowbridge and Kineke (1994); and
3. to document the attenuation of wave energy over an inner shelf with fluid muds and relate that to areas of shoreline accretion and erosion.

APPROACH

The technical approach is a combination of spatial surveys and time-series measurements. The study area is the shallow shelf (< 20 m water depth) from Atchafalaya Bay to ~ 100 km west along the western Louisiana coast. Spatial surveys consisting of a series of shore normal transects will be carried out to define the thickness and extent of fluid muds in relation to water properties (extent of freshwater plume and nearshore mudstream). An instrumented profiling tripod capable of measuring flow and fluid characteristics (Sternberg, et al., 1991) and a second, hand-deployable profiler (CTD plus optical backscatterance sensor) will be used. The tripod is extremely effective in environments with fluid mud because it is able to sample very close to the seabed (appoximately 10 cm), and it can measure very high concentrations of suspended sediment (up to 330 g l^{-1},

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **30 SEP 1997**	2. REPORT TYPE	3. DATES COVERED **00-00-1997 to 00-00-1997**

4. TITLE AND SUBTITLE **The Role of Fluid Mud in Sediment Transport Processes Along a Muddy Coast**	5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Boston College,Dept of Geology and Geophysics,Chestnut Hill,MA,02167**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR’S ACRONYM(S) 11. SPONSOR/MONITOR’S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**5**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

Kineke and Sternberg, 1992). The profiling tripod will be used for spatial surveys (shore normal transects throughout the study area), as well as for tidal time series at salinity fronts while the ship is at anchor. A hand-deployable profiler will be used off small boats in water shallower than approximately 5 m. In addition, the small boat will be equipped with a dual high frequency echo sounder and differential GPS for mapping thickness and extent of nearshore fluid muds.

Time- series measurements will be made in three ways. Anchor station time series will be done by the profiling tripod to determine temporal variability and transport on tidal time scales. An array of six pressure sensors will be deployed to document wave attenuation across the shelf in the presence of fluid muds on the week-to-month time scale. In addition, a new instrumented staff is being constructed to measure flow and fluid characteristics and to document vertical changes in differential pressure, and thus changes in density, from within the mud bed to ~2 m above the bed. This will document changes in fluid mud thickness with passage of gravity waves, as well as the appearance of fluid mud due to settling.

Sampling is scheduled to take place between March 1997 and April 1999, during periods of high and low discharge from the Atchafalaya River and high and low wave activity. The surveys and anchor station measurements will be used to evaluate (1) the influence of river discharge and frontal processes on fluid mud formation and (2) to test the concept of a bearing capacity for a given flow. The pressure sensor array and instrumented differential pressure staff will be used for time-series measurements to evaluate (1) the role of surface gravity waves in fluid mud formation and (2) the effects of the presence of fluid mud on surface gravity wave attenuation.

WORK COMPLETED

The project has been underway for 17 months. Ten pressure sensors for the wave attenuation experiment have been constructed and tested and are ready for deployment during the October 1997 cruise. A prototype differential pressure staff is currently being tested. A Knudsen dual frequency echo-sounder was rented for the first cruise (March 1997) for testing in the environment of the field study. Initial results were promising and a new system has been purchased for use in the remaining experiments. This system is integrated with a DGPS unit and will provide a detailed map of fluid mud location and thickness.A pilot cruise in March 1997 resulted in a major loss of equipment, the profiling tripod, due to a cable break. A new tripod has been rebuilt and is ready for deployment on the next cruise at the end of October 1997.

RESULTS

A hydrographic transect of 11 stations was completed along the axis of the Atchafalaya River using a CTD and OBS and a surface and near bottom Niskin bottle for water samples. Currents measured underway by the ADCP show the transition from very strong surface outflow within the channel (~100 cm/s), to weaker along-shelf flow to the west in water depths of approximately 10 m and greater creating the along shelf mud stream (Fig. 1). Suspended sediment results from this transect are very promising for future work. The transect showed a strong salinity front at the bottom just outside the reef marking Atchafalaya Bay (Fig. 2a,b). Water landward of the reef is fresh throughout the water column with SSC approximately 260 mg l^{-1} at the surface and increasing to 350-400 mg l^{-1} at the bottom. Seaward of the reef the water column is stratified, and evidence of fluid mud was observed at two stations. At these two stations (AR5 and AR6, Fig. 2b) the salinity signal decreased with a decrease in the OBS signal within one meter of the seabed. This was typical of profiles in areas of fluid mud on the Amazon shelf indicative of strong trapping of sediments. With the new profiling tripod, we will be able to sample the fluid mud closest to the bottom to measure concentrations and salinity directly with water samples. The suggestion of fluid mud in the vicinity of a strong bottom front implies the convergence at fronts at least during periods of high discharge could be a realistic mechanism for fluid mud formation. This is an encouraging result for meeting the objectives of determining the mechanisms of fluid mud formation.

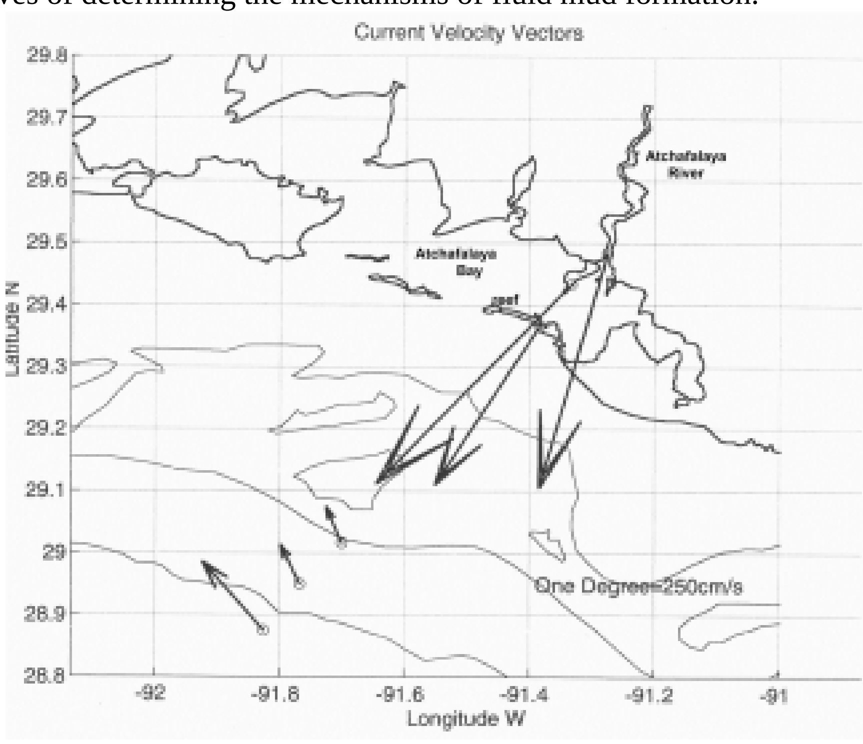

Fig. 1. Near surface currents measured by an Acoustic Doppler Current Profiler, March 1997. Note the strong outflow of the Atchafalaya River and the weaker along shore currents on the shallow shelf that form the "coastal mud stream."

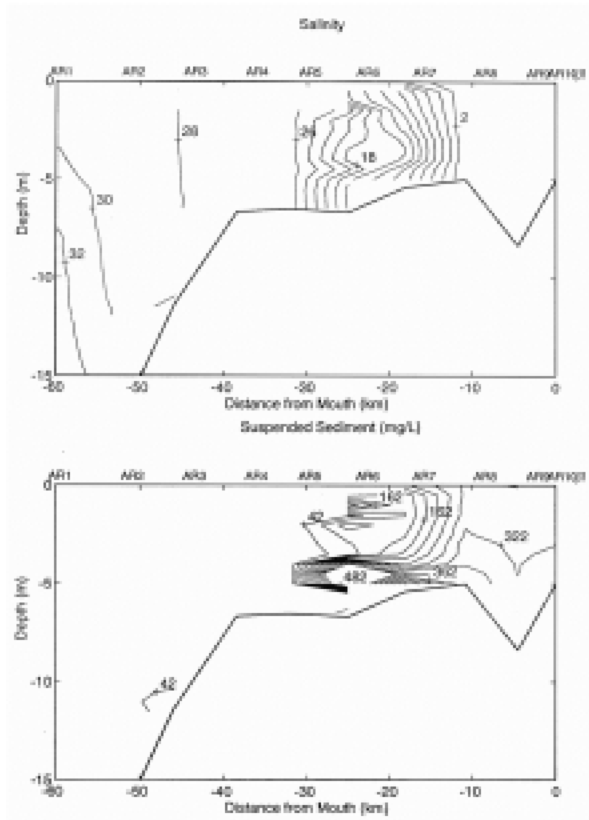

Fig. 2. Cross section of (a) salinity and (b) suspended sediment concentration along the Atchafalaya channel. The apparent decrease in bottom suspended sediment at stations AR5 and AR6 is an artifact of the OBS sensor response in very high concentrations, such as fluid muds. This response can be corrected when calibrated with field samples of fluid mud collected by the pump system on the profiling tripod.

IMPACT/APPLICATIONS

A tremendous amount of research on coastal processes and sediment transport has occurred on sandy beaches; however, muddy coasts are quite common worldwide, especially close to large rivers, and have received relatively little attention by comparison. Wave attenuation is of primary significance for mitigation of shoreline erosion and coastal flooding, and wave attenuation on a muddy coast is directly linked to the characteristics and consolidation state of the muddy substrate, unlike sandy shorelines. In the presence of fluid muds, waves will progressively attenuate as they travel landward, resulting in decreasing boundary shear stresses close to shore, the opposite of what occurs on sandy coasts. The amount of field research done on wave/muddy coast interactions is severely lacking, although a great deal of effort has been done in laboratory flumes and theoretical studies. The proposed field study will provide essential observations for evaluation of the role of fluid muds in sediment transport and our ability to model the effects of wave-mud interaction.

TRANSITIONS

Not applicable at this time.

RELATED PROJECTS

Sediment Trapping and Transport in Estuaries, Southeastern US, National Science Foundation CAREER Development Program, Kineke PI. This project will study sediment transport and trapping mechanisms in three estuaries in the southeastern United States. Understanding the dynamics of sediment trapping, fluid mud formation, and the influence on the transporting flow are directly related to the work proposed here.

Dr. Brent McKee (Tulane University) has ongoing research in the Gulf of Mexico and the Mississippi and Atchafalaya estuaries (state and federal funding). Dr. McKee, a radioisotope geochemist, has made extensive measurements dealing with short and long term accumulation rates on the shallow shelf, which will serve as a guide for areas of fluid mud formation. We have agreed to coordinate our field plans as much as possible.

Dr. Kathleen Ruttenberg (Woods Hole Oceanographic Institution is currently involved in NSF and ONR funded projects to identify and quantify the chemical form of particulate-Phosphorous in the lower Mississippi and Atchafalaya Rivers, at the interface between the Mississippi River and the ocean, and in proximal deltaic marine sediments. She intends to participate in field work planned for 1998.

Collaboration with Dr. Miguel GoÒi, an organic geochemist (University of South Carolina), began in March 1997. Dr. GoÒi participated in our first *Pelican* cruise and collected bottom sediments for organic content and composition analyses. He has recently been funded by the National Science Foundation to investigate the terrigenous inputs of organic matter to sediments from deeper locations in the Gulf of Mexico (including the outer shelf, continental shelf and abyssal plain). We intend to coordinate our field plans to make most efficient use of ship time.

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